Electronic Instrumentation
ENGR-4300 Spring 2002 Section ___

Homework 9
Circuit Components and Magnetic Fields – Inductors, Transformers, and …

1. Inductance of a coil

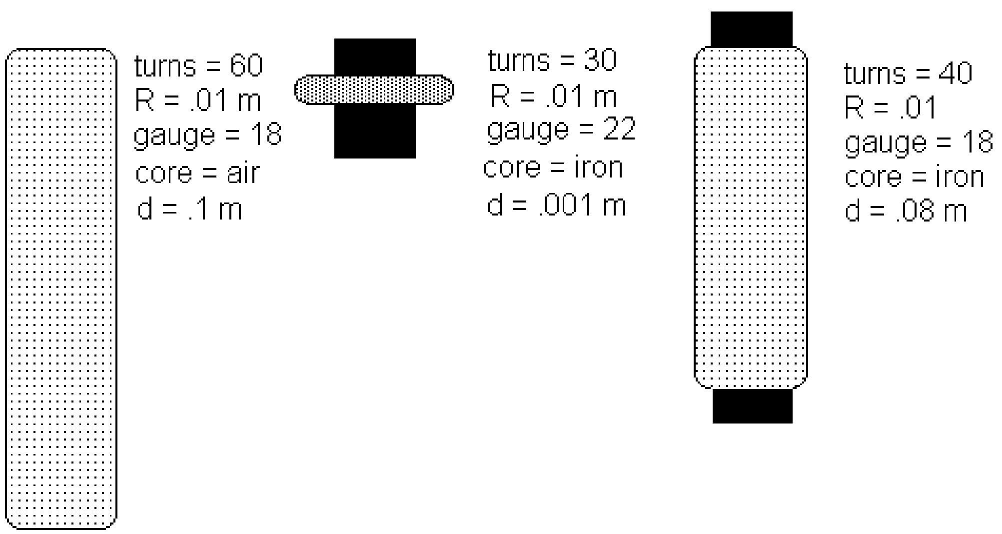
Remembering from your experiment. The equation for an inductor is given by $L = (\mu N^2 \pi R^2)/d$ Henries, where the core cylinder has a radius equal to *R* and we wind a coil *N* times around the cylinder to cover a length d. If the coil is wound like a coin, and not along the length of the core, then the equation is given by $L \cong \mu N^2 R \{\ln(8R/r) - 2\}$, where R is the major radius of the coil and r is the radius of the wire.

Also recall that μ_o has a different constant value depending upon the ferromagnetic properties of the material the inductor is wound around. Here are some typical values for μ .

MATERIAL	μ in Henries/meter
air	$4\pi \times 10^{-7}$
iron	$1200\ (4\pi \times 10^{-7})$

Find the inductance for the following three coils based on the appropriate equation given for L.

a. Coil 1 b. Coil 2 c. Coil 3

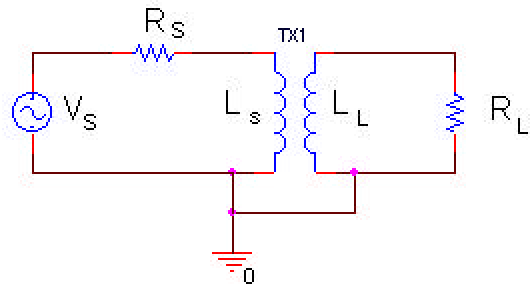


2. Resistance of a Coil

The resistance of a coil is given by R = *l/(sA)* where *l* is the *length of the wire, A is the cross sectional area of the wire* (thickness), and *s is the conductivity* of the wire material. For copper, the conductivity is about 6×10^7 Siemens/meter. Assuming all coils above are made of copper. Find the resistance of each coil.

a. Coil 1 b. Coil 2 c. Coil 3

3. Transformers



Assume coils 1 and 3 are connected together with an iron core and used as a transformer. Use coil 3 for the source inductance and coil 1 for the load inductance. The equation for the impedance of the transformer is given by $Z_{in} = R_L/a^2$ where R_L is the resistance of the load circuit and $a^2 = L_L/L_S$. You can find the current through the loops by applying the following equations: $I_L/I_S = 1/a$ or $N_S I_S = N_L I_L$. Additionally, the induced output voltage can be found using $V_L/V_S = N_L/N_S$. (Assume $R_S = R_L = 50$ ohms and $V_S = 20$ Volts). Find...

a. the inductance of coil 1 when it is wound around the iron core.

b. the input impedance, Zin, of the transformer

c. the output voltage of the secondary coil , V_L

d. the current through the primary coil

e. the current through the secondary coil

e. recalling the equation for power $P = I^2R$, explain how the voltage induced in the second coil could possibly be bigger than the input voltage.

4. Digital Electronics

Read through sections 7.1-7.3 at the following website:
http://www.phys.ualberta.ca/~gingrich/phys395/notes/node117.html

Here is a proof of De Morgan's first law.

$\overline{A \bullet B} = \overline{A} + \overline{B}$ This can also be written ~(A • B) = (~A) + (~B)

A	B	~A	~B	A • B	~ (A • B)	(~A) + (~B)
0	0	1	1	0	1	1
1	0	0	1	0	1	1
0	1	1	0	0	1	1
1	1	0	0	1	0	0

Can you prove De Morgan's second law?

$\overline{A + B} = \overline{A} \bullet \overline{B}$ This can also be written ~(A + B) = (~A) • (~B)

A	B	~A	~B	A + B	~ (A + B)	(~A) • (~B)
0	0					
1	0					
0	1					
1	1					